Case Report

Catheter Ablation of Atrial Tachycardia Originating from the Tip of Right Atrial Appendage

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Right atrial appendage tachycardia is not common and can be eliminated by catheter ablation with a high success rate and low recurrence rate. However, the structural properties of the atrial appendage, including blind-ended structure, abundant trabeculations, and reduced wall thickness could make the procedure of catheter ablation difficult, especially if the focus is at the tip of atrial appendage. We describe a case of atrial tachycardia originating from the tip of the right atrial appendage that was eliminated by catheter ablation in spite of some difficulties in manipulation of the catheter and achieving adequate radiofrequency power.
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Key words: Right atrial appendage, Atrial tachycardia, Radiofrequency ablation

Introduction

Atrial tachycardia arising from the right atrial appendage is not common,[1–4] and some specific clinical and electrophysiologic characteristics have been reported.[1–3] The reported incidence of atrial tachycardia arising from right atrial appendage ranges between 0.6% and 8.0% of focal atrial tachycardia.[1–4] This atrial tachycardia can be eliminated with a high success rate and low recurrence rate by catheter ablation.[1–3] However, the structural properties of the atrial appendage, including blind-ended structure, abundant trabeculations, and reduced wall thickness can make the procedure of catheter ablation difficult and may cause perforation, especially if the focus is at the tip of the atrial appendage.

Case report

A 37-year-old man was referred to our institution because of palpitation. He had been refractory for 2 years to administration of antiarrhythmic drugs including disopyramide, cibenzoline, pilsicainide, bisoprolol, atenolol and verapamil. Results of physical examination, chest X-ray, and echocardiogram were all normal. The 12-lead electorcardiogram showed continuous atrial tachycardia incessantly, and he could not maintain a sinus rhythm. The P wave morphology was positive in the inferior leads and negative in leads V1-V2, with a transition to positivity in the rest of the precordial leads (**Figure 1**). Cardiac computed tomography images showed no significant anomaly, and the right atrial appendage protruded into the right ventricular outflow tract (**Figure 2A**). All antiarrhythmic drugs had been discontinued for a week. After obtaining

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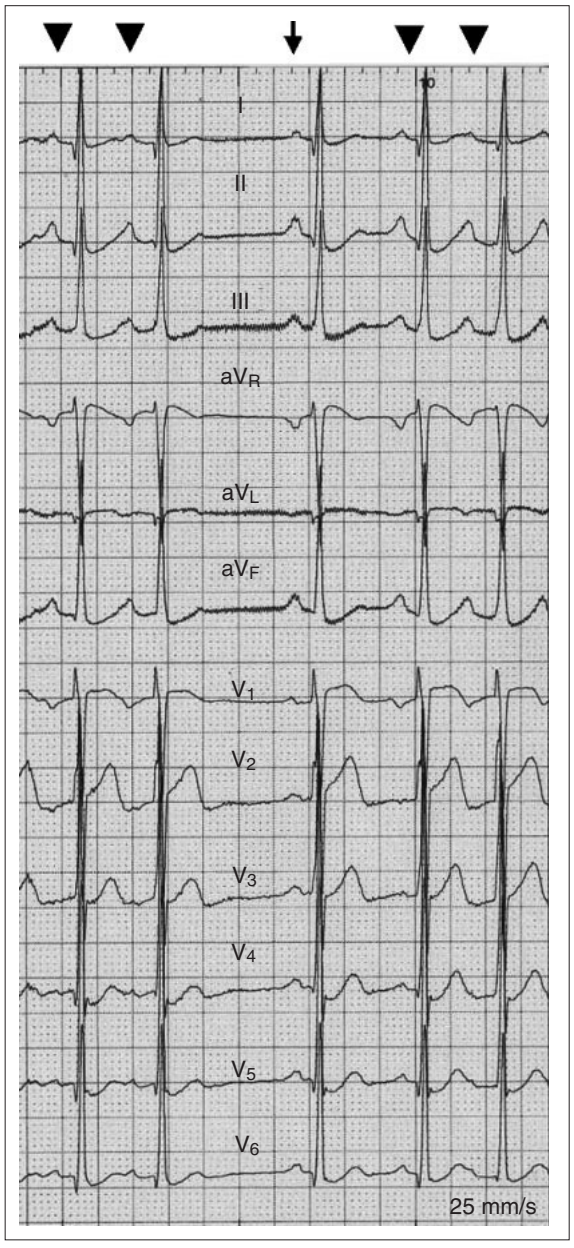

Figure 1
12-lead electorcardiogram showed continuous atrial tachycardia incessantly. The arrow, and arrowheads indicate the P wave originating from the sinus node and the right atrial appendage, respectively.

written informed consent, an electrophysiologic study was performed on the patient.

A 5-French quadripolar electrode catheter (EP star, Japan Lifeline) was introduced through the right femoral vein and positioned in the His bundle. A 7-French catheter (RESPONSE, St. Jude Medical) was introduced through the right jugular vein and positioned such that the distal 10-pole electrode was in the coronary sinus, and the proximal 10-pole electrode was in the high right atrium. A 7-French 20-pole electrode deflectable catheter (CRISTA CATH, Biosense-Webster Inc.) was introduced through the right femoral vein and used for mapping. A 7-French quadripolar deflectable catheter with a 4-mm tip electrode and a magnetic location sensor (NAVI-STAR, Biosense-Webster Inc.) was introduced through athe 8-French long sheath (Swartz, SR 0, St. Jude Medical) inserted from the right femoral vein and used for electroanatomic mapping and ablation. Another electrode catheter with a magnetic location sensor (REF-STAR, Biosense-Webster Inc.) was taped onto the patient's back and used as the location reference for the elecctroanatomic mapping system. A bipolar electrogram from the pair of electrodes in the coronary siuns was used as the timing reference for the mapping system.

The atrial tachycardia was sustained spontaneously with a tachycardia cycle length of 446 msec throughout the electrophysiologic study. About 7 ml of contrast sodium were injected manually from the 8-French long sheath that had its distal end positioned in the right atrial appendage to evaluate its morphology. Right coronary angiography was performed simultaneously, and the distance between the inferior segment of the right atrial appendage and the right coronary artery was small (**Figure 2B**). During injection of the contrast medium to the right atrial appendage, sustained atrial tachycardia was terminated transiently and reproducibly. Bolus injection of 5 milligram of adenosine terminated atrial tachycardia transiently with atrioventricular block. Bolus injection of 5 milligram of verapamil did not effect the atrial tachycardia. The tachycardia could not be terminated with rapid atrial pacing or atrial extrastimuli. Overdrive suppression phenomena were not demonstrated.

The three-dimensional electroanatomic mapping system (CARTO, Biosense-Webster Inc.) showed that depolarization started at the tip of the right atrial appendage (**Figure 3**). Advancing the catheter further into the tip of right atrial appendage was attempted, but it was difficult to judge whether the catheter was positioned at the true tip of the right atrial appendage. ST segment elevation was present on upipolar electrogram at the point where the catheter could not be advanced, suggesting local current injury caused by pressure of the electrode tip against the endocardium of the right atrial appendage. Mechanical interruption of tachycardia during catheter placement was not observed.

Radiofrequency (RF) current was delivered to the area near the tip of the right atrial appendage with a 4-mm tip electrode with a temperature control mode of 50 °C. Endocardial atrial activation where the RF

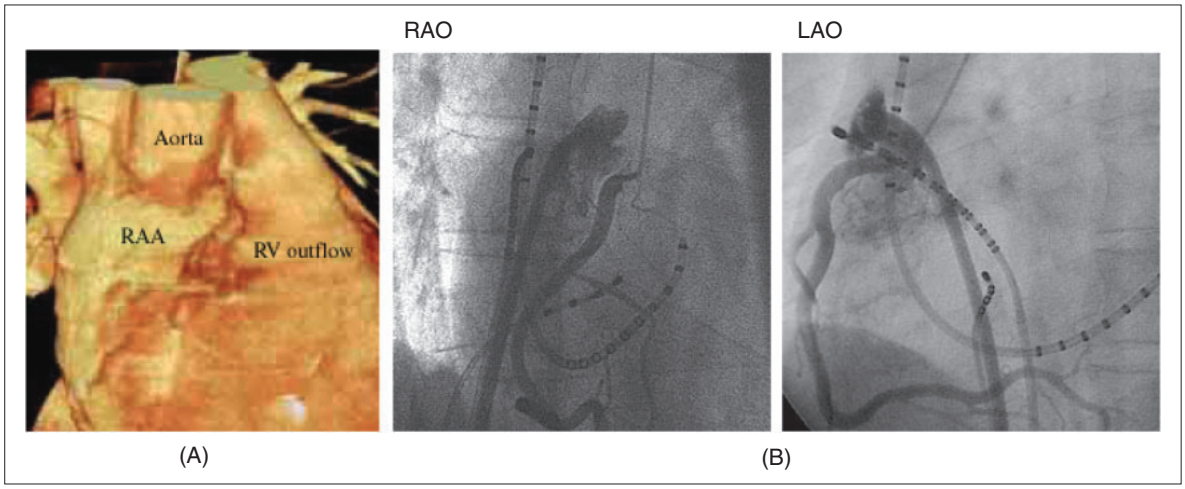

Figure 2
(**A**) Cardiac computed tomography image showed that the right atrial appendage (RAA) protruded into the right ventricular (RV) outflow tract in this patient.
(**B**) The injection of contrast medium into the right atrial appendage and right coronary artery was performed simultaneously. RAO: right anterior oblique view, LAO: left anterior oblique view

current was delivered preceded the onset of the P wave by 39 msec (**Figure 4**). To maintain the electrode temperature at 50 °C, RF power output was limited to 7 W, suggesting low blood flow around the ablation electrode within the right atrial appendage. To achieve higher RF power output, the limitation of temperature was increased to 60 °C, but this patient had severe chest pain when we applied RF energy. Fifteen milligram of pentazocine was administrated to relieve the pain, but he strongly refused further application of RF energy. Sustained atrial tachycardia could not be eliminated in this first session.

Because he had continued to complain of palpitation, we planned a second session of catheter ablation or surgical excision of the right atrial appendage. Ten days after the first session of catheter ablation, incessant atrial tachycardia disappeared without any antiarrhythmic drugs. This patient has been kept in sinus rhythm without any antiarrhythmic drugs during the subsequent 12 months.

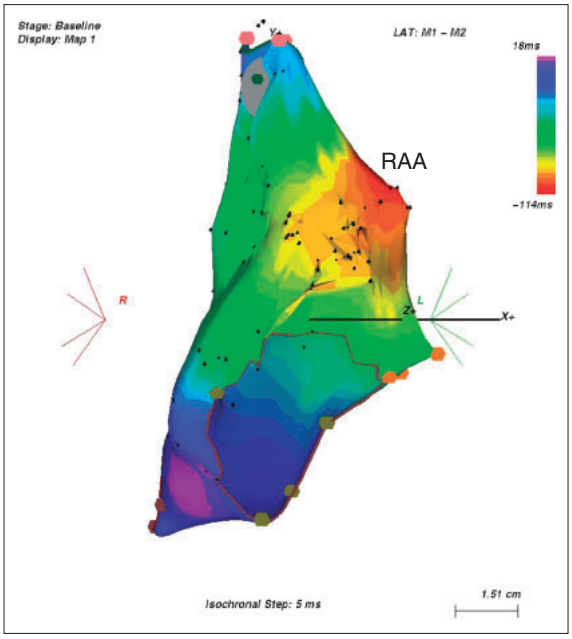

Figure 3
Three-dimensional electroanatomic mapping system (CARTO, Biosense-Webster Inc.) showed that depolarization started at the tip of the right atrial appendage (RAA).

Discussion

Right atrial appendage tachycardia represents not only a particular anatomic origin of atrial tachycardia, but also a group of tachycardias with specific clinical, electrocardiographic, and electrophysiologic characteristics.[1–4] As seen in our case, right atrial appendage tachycardia has been reported to be more likely in younger male patients, and is more frequently incessant compared with other atrial tachycardias.[1–3] The mechanism of right atrial appendage tachycardia is not known. Remnant autorhythmic tissue may be the source of this arrhythmia. Right atrial appendage with triggered activity has been reported as a source of atrial tachycardia.[5] In our case, adenosine could terminate atrial tachycardia transiently, suggesting that the mechanism of this tachycardia might be triggered activity. The right atrial appendage protruded and the tip of the right atrial appendage was anatomically

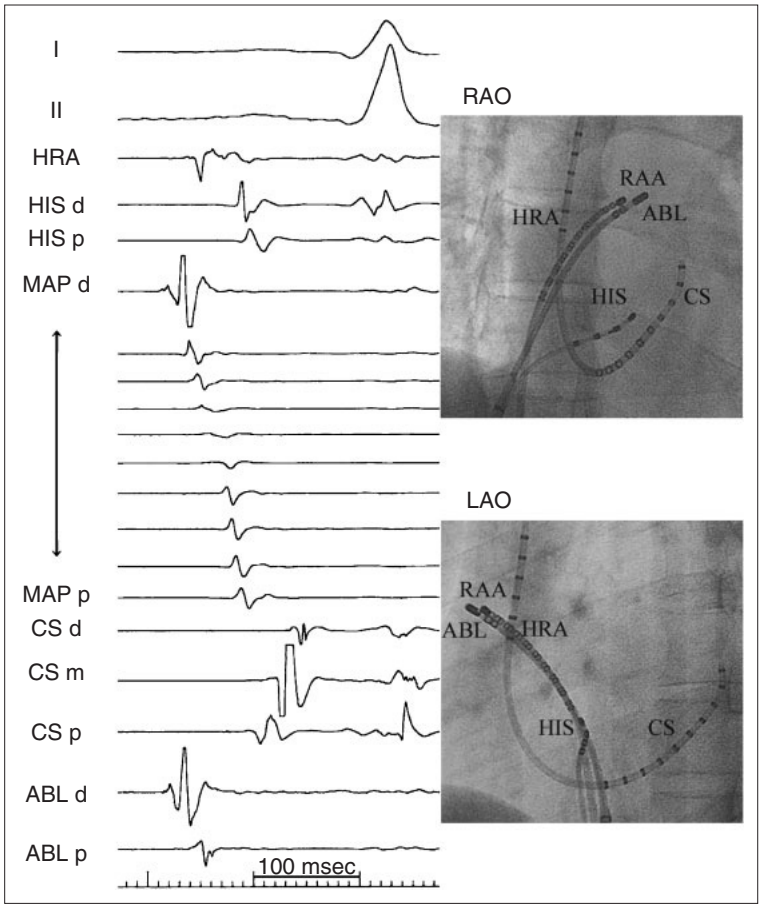

Figure 4
Intracardiac electrograms and fluoroscopic images where the radiofrequency current was delivered during sustained atrial tachycardia. The distal end of the 7-French 20-pole electrode deflectable mapping catheter (MAP) and ablation catheter (ABL) was deeply advanced into the right atrial appendage (RAA).
HRA: high right atrium, HIS: His bundle, CS: coronary sinus, d: distal, m: middle, p: proximal, RAO: right anterior oblique view, LAO: left anterior oblique view

close to the ventricular outflow tract in our patient. The mechanism of ventricular outflow tract tachycardia might be triggered activity and can be suppressed by adenosine.[6] The abnormal tissue with triggered activity might be connected to the right atrial appendage but not to the ventricule and may cause atrial tachycardia.

Other electrophysiologic characteristics of right atrial appendage tachycardia included a greater proportion of successful ablations and a lower incidence of recurrence compared with other atrial tachycardias.[1–3] However, the structural properties of the atrial appendage, including blind-ended structure, abundant trabeculations, and reduced wall thickness can make the procedure of catheter ablation difficult, especially if the focus is at the tip of atrial the appendage. The wall of the right atrial appendage is very thin and cardiac tamponade caused by perforation could lead to severe complications. It is important to be aware that the right coronary artery runs close to the inferior portion of the right atrial appendage. Advancing the catheter into the tip of the right atrial appendage may be prevented by abundant trabeculations. Advancing the catheter further into the tip of the atrial appendage should be performed carefully to avoid perforation, especially when ST segment elevation suggests local current injury caused by pressure of the electrode tip against the endocardium.[7] We assessed that the origin of atrial tachycardia was the tip of right atrial appendage, because the deepest position where we could advance the mapping catheter in the right atrial appendage was the earliest atrial activation site in tachycardia. However, because mechanical interruption of tachycardia was observed by injecting contrast medium but not by catheter placement in the right atrial appendage, we may not have placed the catheter deeply enough in the tip of the right atrial appendage in our patient. And the origin of atrial tachcardia in this case might not exist in the true tip of right atrial appendage. Abundant trabeculations and low blood flow of the right atrial appendage may also be the cause of inadequate power delivery of conventional ablation catheters and the need for an irrigated catheter.[1–3] Because of difficulty achieving adequate power, irrigated catheters were subsequently employed in 7 of 10 cases of right atrial appendage tachycardia.[1]

Irrigated catheters were not approved for clinical use in Japan in our case. The usefulness of a large-tip ablation catheter was also suggested to apply sufficient energy for ablation in the right atrial appendage.[8] However, avoiding the use of an irrigated catheter for the first ablation is suggested, because of the risk of perforation of the right atrial appendage.[2] Our patient complained of severe chest pain when the limit of temperature was increased to 60 °C. Damage to the pericardium might easily occur from the RF energy because of the thin wall and low blood flow of the right atrial appendage.

In our patient, incessant atrial tachycardia had been eliminated about 10 days after RF catheter ablation without any antiarrhythmic drugs. The mechanisms for the delayed effect after RF ablation are unclear. The effects of the ongoing healing process of the RF lesion, such as local inflammation and edema, may be associated with fibrosis formation that leads to extension of the lesion and elimination of atrial tachycardia.[9] RF energy on the area of preferential conduction may eliminate focal atrial tachycardia.[10] Some delayed effect of RF energy to the area of preferential conduction may have eliminated incessant atrial tachycardia in our patient.

Successful surgical excision of the atrial appendage in atrial tachycardia has been reported without the use of cardiopulmonary bypass.[5,11] The act of clamping the right atrial appendage abruptly terminated the atrial tachycardia, and after excision, atrial tachycardia could not be induced.[5] Because of the morphology of the atrial appendage, it might be more easily and safely excised compared with other causes of atrial tachycardia. In recent years, minimally invasive techniques including excision of the left atrial appendage using small bilateral thoracotomies with thoracoscopic assistance have been developed especially for patients with atrial fibrillation.[12] Surgical therapy should be considered especially in the case of atrial tachycardia originating from the tip of the right atrial appendage that cannot be eliminated by catheter ablation.

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